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Program Outline

for

Egg and Larval Investigations and Continuation of Impact Evaluations of Damages by Potential Oil Accidents on the Most Important Fish Species North of 62°N.

Institute of Marine Research of the Directorate of Fisheries, Bergen

May 1983.

SEC 5-25 (Rev. 82/11)

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Contents

	Page Orig.	Transl.
1. History	1.	3
2. What do we know today?	2.	4
3. Why is our knowledge not sufficient?	3.	6
4. What should we know more about?	4.	7
a) Spawning progression of the most important species	4.	7
b) Vertical distribution of the spawning products of various species	5.	8
c) Identification of fish eggs	5.	8
d) Detailed pattern of the coastal current	5.	9
e) Distribution of eggs and larvae of the most important species	6.	9
f) Vulnerability of fish larvae	6.	10
g) Instrumentation and data processing	7.	11
5. Conclusion	8.	12
6. Program outline	9.	13
7. Cost estimate	11.	15

1. History

In a letter from the Ministry of Fisheries to the Director General of Fisheries dated August 10, 1982, the Institute of Marine Research was asked to analyze "the long-term consequences with respect to quantity and value on Norwegian-Arctic cod of an oil spill on Tromsoflaket, the Traena Bank and the Halten Bank, respectively". p.1

At a meeting in the Ministry of Fisheries on October 14, 1982 of the working group for fisheries under the joint Committee for Petroleum Finds in the North (SPN), the Institute of Marine Research gave an account of the models available for impact (consequence) evaluations of an oil spill as presented in NOU 1980:25 (Norw. Offical Reports). In the account it was emphasized that rough estimates like this were only suitable to give an estimate of a "worst possible case". It was specified that it was necessary to gain considerably more detailed knowledge if an impact evaluation was to be used for more than a rough sketch of the possible consequences of an oil spill on a fish population.

In a reply to a request from the Director General of Fisheries dated October 20, 1982, the Institute of Marine Research presented a brief on the requirements for additional information on egg and larvae concentrations, and indicated at the same time that the Institute will present a proposal for a program for improving the data base for impact studies.

At a meeting in the working group for fisheries under SPN, February 7, 1983, spokesmen from the Institute verbally

outlined a research program and estimated the costs for such a program. The working group would also like to tie in with this program "a further definition of the periods of the year when special caution must be observed in petroleum activities from marine biological considerations".

2. What do we know today? p. 2

The Institute of Marine Research has participated in presentations of the problem oil/fish and possible consequences of an oil accident in a number of public documents. The problems are discussed especially in Parliamentary Reports No. 25(1973-74) and no. 91 (1975-76), no 65 (1977-78), no 57 (1978-79) and NOU (Norw. Off. Rep.) 1980:25. These reports cover: the possibilities for oil to damage marine life and especially fish, biologically important periods and areas to the north of 62^{o}N, spawning times for the most important fish species on the continental shelf north of Stadt and the magnitude of damage from possible oil accidents is estimated.

In 1977-78 a number of researchers at the Institute of Marine Research carried out an evaluation of catastrophic spills of oil and developed in that connection a model of an impact analyses on the effects of oil spills on fish resources. (Appendix 1). The analysis is based on a modelled drift of oil and the degree of overlap with egg and larvae concentrations. The model assumes that eggs and larvae found under floating oil younger than 15 days old will die, and that the percentage of overlap between such oil and the egg/larvae concentrations will give the reduction in the actual fish stocks.

A blow-out on the Halten Bank in April 1976 would have resulted in ca. 1/3 of the registered herring larvae having been exposed to oil when it was younger than 15 days old and would therefore have perished according to our criteria (NOU 1980:25). The effect on the 1976 year-class, if 1/3 of the year class had been destroyed as a result of an oil spill, can be calculated from the model for Atlanto-Scandia herring in the Institute of Marine Research. The model that assumes that there is a relationship between spawning stock and recruitment shows that the loss as the result of a reduction in a year class accumulates and that the maximum loss will come in 20 years. For the 1976 year class to have a one-third reduction and with the assumption that there is no fishing on the stock, the model will give an accumulated loss in 20 years of 1,141,000 tonnes. By using an economic model with an assumed 7% interest, the current value of the accumulated loss can be calculated. This represents a first hand loss today of ca. 600 million kroner. p. 3

On the basis of the Institutes' post-larval studies on Tromsoflaket in June-July 1980,81 and 82, the Central Institute for Industrial Research (SI) estimated the area of overlap between an estimated oil spread as a result of a "blowout" on Tromsoflaket and the distribution of cod larvae. The overlapping area for oil younger than 15 days, which is deadly for eggs and larvae in the sea under the oil, would give a reduction of cod larvae on Tromsoflaket in 1980 of 51% in 1980, 42% in 1981 and 28% in 1982 with an average of 40% for the three years.

3. Why is our knowledge not sufficient?

The data base that the Institute of Marine Research has based their above-mentioned evaluations on, has little analyzability in the description of the horizontal detailed data and vertical distribution of fish eggs and larvae and of food organisms for the fish larvae. A more detailed breakup is necessary if detailed impact evaluations are to be done. The two projects supported by NFFR, "The first food uptake by cod larvae" and "Fish larvae nutritional status and transport in the coastal current" at the Institute of Marine Research, have shown that there are large variations in egg and larvae distributions over short distances and by depth. Such observations assume a completely different instrumentation than that traditionally used in egg and larval studies. Development of instruments was an important part of the cod larvae projects and showed that it is possible to come up with new plankton gear which, with some more development, also could be used in routine investigations.

The cod larvae projects have demonstrated the necessity of detailed knowledge on distribution and drift of eggs, larvae and food animals. The results show that it is possible to refine both the actual description of spawning products and food animals in time and space and the models for the transport of the spawning products and thereby possibilities for survival.

In our impact model used so far, a "worst possible case" has been the point of origin. We have therefore assumed that overlap between 15 days old or younger oil and fish larvae

p.4

lead to all larvae under the oil perishing. However, damage only occurs when the oil or oil components come in contact with the larva. This means that knowledge of the distribution in the water column both of spawning products and of oil, is a necessity if the estimates for possible damage effects are to be approximately correct.

Knowledge of details in the distribution and transportation patterns of spawning products can be of importance if it is possible to choose between several drilling locations. Such detailed knowledge will also be very necessary if the correct methods of combat, in a fisheries biological context, could be used in an oil spill. Factors such as time and assumed duration of the oil leak, locality, if the oil is leaking out at the bottom (the blow-out in the Gulf of Mexico in 1979) or at the surface from the platform (the Bravo blow-out in the North Sea in 1977) must be compared with an assumed distribution pattern for the spawning products of the most important species.

4. What should we know more about?

a) Spawning progression of the most important species.

The spawning progression curve describes how the number of newly spawned pelagic eggs on a spawning ground varies during the spawning period. From this curve it is possible to estimate when the peak in spawning occurs. Together with knowledge on egg drift, which tells us something on where peak spawning occurs, the spawning progression

studies are therefore important for 1) localization of the larval studies and 2) the quantitative evaluation of the larval studies (quantities of eggs, the length of the spawning season, special conditions during the drift of eggs, for example weather and temperature conditions etc.).

b) Vertical distribution of the spawning products of various species. p. 5

The vertical distribution of fish eggs and larvae is chiefly dependent on wind strength and physical properties of eggs and larvae which can vary considerably from species to species.

The cod larva projects have given a good basis for studies also of other species, and the Institute has accumulated considerable expertise with respect to use of new equipment in order to measure the vertical distribution of eggs and larvae.

If an impact evaluation of the damage of a possible oil accident shall be more realistic, the distribution of eggs and larvae in the water column must be included as an important factor.

c) Identification of fish eggs

Pollock and Norway Pout eggs cannot be distinguished by normal analysis. Haddock and cod eggs also can not be separated in their young stages. It will therefore be necessary, as a part of the program, to find an identification technology that can easily be used in the field.

d) Detailed pattern of the Coastal Current

The continental shelf areas north of 62°N have a completely central role as spawning areas and in part growing areas, for the most important fish species in the North-east Atlantic. The Norwegian Coastal Current transports the spawning products to the growing areas further north at the same time as it also carries the necessary food organisms for the fish larvae in the first critical period of life. The general flow of the coastal current is known while the knowledge of the detailed current pattern only is known for some areas, especially the Halten Bank and the West Fjord. With the help of satellite-positioned drifting buoys, combined with hydrographic observations from ships, it is possible to map out the detail in the current systems along the coast. In order to be able to "raise" the alert regarding transportation and spreading of eggs over the coastal banks, we must obtain detailed knowledge on the areas we do not already know. We must therefore concentrate on studies based on the use of satellite-positioned drifting buoys. p. 6

e) Distribution of eggs and larvae of the most important species.

The Institute of Marine Research has since 1949 carried out annual egg-and larval investigations over the bank areas north of 62°N. These investigations have had other purposes than to describe details in distribution of the spawning products of the various species. We have still been able to use the results from these studies for the rough

impact analyses the institute has already carried out and which are given in the above mentioned Parliamentary Reports. The studies by the Institute have especially been concentrated on herring, cod and capelin and have to a lesser degree caught eggs and larvae from other important species such as haddock, pollock, ling, cusk, and argentine. The investigations so far have also been concentrated on certain areas during limited time periods so that our knowledge of the egg and larval distribution of all species does not cover the whole of the area and the time when the fish are especially sensitive to oil pollution.

When the herring larvae are 2-3 months old they begin to form schools and have mobility enough to escape from a polluted water mass. We count on a corresponding development also for the other important fish species. Spawning and hatching periods are also different for the various species and spawning times, and spawning areas are different within each species. This means that the time period when we can find susceptible stages is somewhat more than 2-3 months. In order to cover the most important periods it will be necessary to do continuous monitoring in the period March-June in the area More-West Fjord and for the area West Fjord-Varanger Fjord in the period March-July. It will also gradually be desirable to do observations from the fixed installations on the oil fields.

f) Vulnerability of fish larvae

The first condition for an oil pollution incident to have

have consequences for a fish population, is that the oil should come in contact with the passively drifting fish eggs and larvae. At a certain size, a fish larva will have mobility enough to be independent of the movements of the water masses. It will then be able to avoid an oil-polluted water mass and thereby survive. Experimentally it must be determined how large a fish larva must be in order to be able to avoid an oil-polluted water mass and if it then escapes. p. 7

g) Instrumentation and data processing.

In order to be able to describe the vertical distribution of fish larvae and plankton with greater detail, it is essential to understand the processes that guide the survival of fish larvae and therefore also the effect of pollution. Such details require that a new type of instrumentation is taken in use. These must be instruments that quickly and accurately register the distribution through water. In connection with the cod larvae projects at the Institute of Marine Research, special work has been underway to adapt and to develop equipment for studies of the vertical distribution of eggs, larvae and food animals. This equipment must be further developed so that it can be included as a routine instrument in the proposed studies.

Greater accuracy and analyzability of recordings increase the data set considerably and require effective data processing. If the collected data from the proposed biological,

physical and chemical studies are to be compared and further studied for use in impact models, it would require a considerable programming effort, increased data capacity and increased use of graphical equipment.

5. Conclusion

- The institute of Marine Research has earlier presented impact assessments of oil activities north of 62°N and possible damage to the fish resources. These are mentioned particularly in Parliamentary Reports no. 25 (1973-74), no. 91 (1975-76), no. 65 (1977-78) no. 57 (1978-79) and NOU (Norw. Off. Reports) 1980:25. p. 8
- We feel that it is possible to refine the consequence (impact) models for the effect of an oil accident on fish resources. A better model will give more reliable estimates of damages.
- A detailed description of the horizontal and vertical distribution of the most important fish species at their most vulnerable young stages can be important information for the future choice of drill locations as well as for the choice of oil dispersal agents for a possible oil spill.
- The Institute of Marine Research assumes that work is continued on an oil drift model by the Norwegian Meteorological Institute and the Institute for Continental Shelf Studies (IKU). We assume that this model can give us a map over oil drift patterns and the oil-contaminated water masses for the time periods and the areas in which vulnerable fish resources are being observed.

6. Program Outline

- The bulk of the effort will be expended in field studies which we presume will cover the areas More-West Fjord in the period March-June and West Fjord-Varanger Fjord in March-July. The monitoring should continue over a 5-year period.
- The material should be processed onboard. The distribution, horizontally and vertically, will be presented on maps.
- The transportation pattern is observed simultaneously with satellite-positioned drifting buoys and with hydrographic observations from research vessels. The distances to be covered with a vessel are so large that it is necessary to have drifting buoys which describe the drift of the water masses and therefore the drift of the spawning products, between each coverage with vessels.
- It is assumed that within the framework of the investigation, detailed studies of the spawning progression of the individual species will be made. This requires a high degree of flexibility in the choice of stations and station density.
- It is assumed that the vessels are equipped with gear to describe the vertical and horizontal distribution of eggs and larvae, nutrient conditions and hydrography. We assume that six people from the Institute of Marine Research will be manning the vessels.
- The distribution maps are compared with assumed oil drift patterns for the same time period, and the consequences (impacts) are calculated. These will constitute time-dependent

overviews which will be used for impact evaluations for the individual years.

- In addition there will also be studies carried out on the nutrient conditions for fish larvae and prey animals, to make it possible to consider an assumed competition for nutrients between bacteria that break down oil and phytoplankton and thus evaluate the production possibilities in an affected water mass.
- The studies that the Institute of Marine Research already carries out on eggs and larvae will be incorporated in the program. Similarly, the Institute's monitoring program of the pelagic production system north of 62°N will be coordinated with this program. p. 10
- Further work will be carried out on development of instruments and development of data programs for processing and adapting the collected material for use in the impact evaluation. It is presumed that sufficent data capacity and peripheral data equipment, especially graphical, is acquired for this.
- Experimental work will be carried out in order to find suitable methods of identification in order to distinguish between pollock and Norway Pout eggs. Studies will be carried out at the Institute in order to find the size and age when fish larvae no longer are vulnerable to an oil polluted water mass either by avoiding the oil or that they are no longer susceptible.

7. Cost estimate

p. 11

a) Yearly expenses in 1000 kroner

Cruise expenses, charter of vessel	kr.	4,000.-
Hire of professional help:		
2 researchers	"	400.-
4 assistants	"	600.-
Instrument and program development	"	1,000.-
Operation of 15 Argos satellite-positioned drifting buoys	"	300.-
Replacement for assumed loss of 3 Argos buoys	"	225.-
	kr.	6,525.-

b) One-time expenses in 1000 kr.

15 Argos satellite-positioned drifting buoys	kr.	1,125.-
2 Mocness plankton nets	"	400.-
4 Gulf III plankton gear	"	100.-
2 CTDprobes w/water collecting wreath and transportable winch w/cable and necessary data equipment	"	1,400.-
Information retrieval and graphic equipment	"	2,000.-
	kr.	5,025.-